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NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation *March 6, 2001*

Captain Suffers a Heart Attack at a Structure Fire and Dies 12 Days Later - Illinois

SUMMARY

On July 23, 1998, a 56-year-old male Captain responded to a fully-involved structure fire. After stretching a 250-foot section of 2½-inch hoseline and attacking the fire, the Captain experienced crushing substernal chest pain. He walked to the on-scene ambulance, where paramedics initiated treatment for a heart attack and transported him to the hospital. Shortly after arriving at the hospital, the Captain had a cardiac arrest. Cardiopulmonary resuscitation (CPR) and advanced life support (ALS) resuscitation efforts were successful, and an intravenous thrombolytic agent (tissue plasminogen activator) was given. The next day the Captain underwent a cardiac catheterization which showed severe coronary artery disease (CAD) and a stent was placed in the left anterior descending (LAD) coronary artery. He was discharged 5 days later to undergo coronary artery bypass surgery at some point in the future. On August 4, 1998, at approximately 1800 hours, the Captain had a witnessed cardiac arrest while recovering at home. Despite CPR and ALS administered by the ambulance paramedics and by hospital personnel in the emergency department, the Captain died. The death certificate, completed by the County Coroner, listed myocardial infarction (otherwise known as a heart attack) as the immediate cause of death, due to severe atherosclerotic cardiovascular disease. The autopsy, performed by the Deputy Chief Medical Examiner, showed a large heart (cardiomegaly), severe coronary artery disease (CAD), and evidence of old and recent myocardial infarctions.

Other agencies have proposed a three-pronged strategy for reducing the risk of on-duty heart attacks and cardiac arrests among fire fighters. This strategy consists of (1) reducing physical stress on fire fighters, (2) screening to identify and subsequently rehabilitate high-risk individuals, and (3) encouraging increased individual physical capacity. Issues relevant to this Fire Department include

- ***Fire Fighters should have <u>mandatory</u> annual medical evaluations and periodic physical examinations to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.***
- ***Exercise stress tests should be incorporated into the Fire Department's medical evaluation program.***
- ***Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at

www.cdc.gov/niosh/firehome.html
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Captain Suffers a Heart Attack at a Structure Fire and Dies 12 Days Later - Illinois

INTRODUCTION AND METHODS

On August 4, 1998, a 56-year-old male Captain died 12 days after suffering a heart attack while fighting a structure fire. On April 19, 2000, NIOSH contacted the affected Fire Department (FD) to initiate the investigation. On September 18, 2000, a Safety and Occupational Health Specialist and a physician from the NIOSH Fire Fighter Fatality Investigation Team traveled to Illinois to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed the following either in person or by telephone:

- FD Personnel Director
- FD Employee Assistance Program representatives
- FD Medical Director
- FD Commander of the Medical Section
- Victim's wife
- Union local
- Crew members on duty with the victim

During the site visit NIOSH personnel reviewed the

- FD policies and operating guidelines
- FD training records
- FD annual report for 1998
- Victim's personnel file at the FD
- FD physical examination protocols
- Ambulance response report
- Hospital records
- Death Certificate
- Autopsy report

INVESTIGATIVE RESULTS

Incident. On July 23, 1998, the victim reported for work to Engine Company 78 at 0800 hours. The day was spent changing hose loads, performing company drills (runouts), conducting inspections, and preplanning incident response in their "first due" response district. Prior to 2200 hours, Engine 78 was dispatched to three calls: an ambulance assist at 1657 hours, a still alarm at 2118 hours, and a rubbish fire at 2138 hours. At 2153 hours, 911 dispatched the involved Fire Department to a fire in a three-story apartment building of unprotected ordinary construction, measuring 40 feet by 125 feet, that was undergoing remodeling and was unoccupied. Command Van 272, Battalion 5, Battalion 9, Battalion 10, District Chief 223, Ambulance 31, Engine 59, Engine 78, Engine 83, Engine 110, Truck 22, Truck 47, Tower Ladder 21, Squad 2, and the Office of Fire Investigation were dispatched on a still alarm. Units began to arrive on the scene at 2155 hours and found the structure to be fully involved and impinging on exposures (adjacent structures). Engine 78 (Captain [the victim], Engineer, and three Fire Fighters) arrived on the scene at 2212 hours, was placed in Sector 3, and backed into the nearby alley. The victim, wearing full turnout gear (¾-length boots, coat, helmet, Nomex hood, and gloves) and self-contained breathing apparatus (SCBA), stretched a 2½-inch hoseline to the north side (rear) of the structure and a Fire Fighter stretched a 2½-inch hoseline to the south side of the structure. Engine 78 then repositioned in a parking lot and two Fire Fighters stretched a 4-inch supply hose approximately 150 feet across the street to the hydrant. Then those same two Fire Fighters connected another 4-inch supply hose from Engine 78 to Truck 47, positioned nearby, to provide water for ladder pipe operations. At 2215 hours, the Incident Commander (IC) requested the alarm be upgraded to a still and box alarm, and shortly thereafter, upgraded again to a "2-11," or a two-alarm fire. Additional personnel and apparatus were dispatched (Engine 55, Engine 70, Engine 102, Engine 124, Truck 25, Truck 38, Tower Ladder 10, Battalion 7, and Battalion 11) for a total of 90 FD personnel eventually responding.

Once his 2½-inch hoseline was charged, the victim applied water to the fire building and to the exposure.

At approximately 2230 hours, the victim, with help from two Fire Fighters, repositioned his hoseline to the south side of the structure. At approximately 2240 hours, the victim asked the Fire Fighters to watch his light and walked away. Fire Fighters took control of his 2½-inch hoseline. As the victim walked toward the Incident Commander, he grabbed his chest. The IC walked the victim to the on-scene ambulance where he grabbed his chest again and gasped for air.

Paramedics evaluating the victim noted his substernal crushing chest pain. Vital signs revealed a pulse of 96, a respiratory rate of 22, and a blood pressure of 138/70. Initial assessment was of a heart attack (myocardial infarction) and he was given three sublingual (under the tongue) nitroglycerine tablets and intravenous morphine. This provided minimal relief of his pain. During transport his vital signs were stable, and the victim arrived at the hospital's emergency department at 2250 hours. An EKG revealed ST segment elevations in the anterior portion of the heart, consistent with an acute myocardial infarction (MI). Shortly thereafter, the victim's heart rhythm deteriorated into ventricular fibrillation (a life-threatening heart rhythm) for which he was shocked (defibrillated) six times over the course of several minutes. Other ALS procedures were followed, including intubation and CPR, and an intravenous thrombolytic agent (tissue plasminogen activator) was given. This treatment was successful at resuscitating the Captain, and serial EKGs and cardiac enzymes over the next 36 hours confirmed the occurrence of an MI. On July 24, 2000, the Captain underwent a cardiac catheterization, which showed severe CAD (80% stenosis of the proximal LAD with fresh thrombus [blood clot]; 80-90% stenosis of the diagonal; 80% lesion of the circumflex; and 50% stenosis of the right coronary artery) and an ejection fraction of 30% with no movement (akinesis) of various regions (anterolateral, apical, and septal). This lack of movement in various regions is also consistent with an MI. A stent was placed in his LAD, and subsequent coronary artery bypass surgery after a 1- to 2-month recuperation period was recommended. His subsequent hospital course was unremarkable, and he was discharged on July 29, 1998, with numerous medications.

On August 4, 1998, at approximately 1800 hours, the Captain collapsed in his kitchen. Immediately prior to his collapse, he had not expressed any prodromal symptoms such as chest pain or shortness of breath. An ambulance was called, and despite CPR and ALS administered by the ambulance paramedics and by hospital personnel in the emergency department, the Captain died. He was pronounced dead at 1907 hours.

Medical Findings. The death certificate, completed by the County Coroner, listed a myocardial infarction as the immediate cause of death, due to severe atherosclerotic cardiovascular disease. Pertinent findings from the autopsy, performed by the Deputy Chief Medical Examiner, are

- a large heart (cardiomegaly) weighing 535 grams
- an old posterior MI
- a recent anterior septal MI
- severe coronary artery disease (CAD)
- Stent in the LAD with 60-75% focal occlusion proximally
- 70-80% occlusion proximally of the circumflex artery
- 50-60% occlusion of the right coronary artery.

Medical history indicated that the victim had three coronary artery disease (CAD) risk factors: age, male gender, and smoking. FD medical records noted many occupational injuries over his 31-year career, but no periodical medical evaluations or exercise stress tests (EST). His last visit to FD medical clinic was in 1989, and his last visit to his private physician was in 1996. Prior to his MI, the

victim did not relate any symptoms suggestive of ischemic heart pain (angina) to his wife, friends, or coworkers.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the Fire Department consisted of 4,979 uniformed career personnel and served a population of 3 million residents in a geographic area of 228 square miles. There are 100 fire stations. Fire fighters, including the victim, work on one of three shifts from 0800-0800 hours, 24 hours on duty, 48 hours off duty.

In 1998, the Department responded to 174,050 calls: 5,414 structure fires, 6,670 vehicle fires, 11,611 other fires, 87,580 emergency medical treatment calls, 8,749 other rescue calls, 13,803 hazardous condition calls, 66 overpressure/rupture calls, 5,488 service calls, 5,164 good-intent calls, 5,112 malicious calls, 22,608 other false calls, 1,785 other calls. Engine 78 responded to 1,422 fires and 876 nonfire emergencies in 1998.

Training. The Fire Department requires all new fire fighters to pass a preemployment physical examination, a timed physical agility test, and a written civil service test. Once hired, the fire fighter must complete the 6-month Fire Fighter II and emergency medical technician (EMT) training, which is given at the City Fire Academy. Recruits are tested by State personnel. Once recruit training is completed, the Fire Fighter is assigned to a shift. Subsequent training is conducted on-shift. There is a no minimum state requirement for fire fighter certification or for annual fire fighter recertification, although there is for Hazardous Materials (Hazmat), CPR, emergency medical technician (EMT), and First Responder. The victim was certified as a Fire Fighter II, Driver/Operator, Hazmat, and Fire Inspector, and he had 31 years of fire-fighting experience.

Preemployment/Preplacement Evaluations. The Department requires a preemployment/preplacement medical evaluation for all new hires, regardless of age. Components of this evaluation for all applicants include the following:

- Physical examination
- Blood tests: Complete Blood Count (CBC), Metabolic profile, Lipid profile, Pregnancy test for female applicants, Hepatitis B and C screen, Syphilis test
- Chest X-ray
- Pulmonary function tests (PFT)
- Exercise stress test: achieving a level of at least 10 metabolic equivalents (METs) on a treadmill using the Bruce protocol (stage 3)
- Dip-stick urinalysis
- Drug Screen: urine and hair
- Skin test for tuberculosis
- Audiogram
- Vision test: distant and near vision

These evaluations are performed by a contractor, and the results are reviewed by the FD physician, who makes a determination regarding medical clearance for fire-fighting duties and forwards this decision to the City's personnel director.

Periodic Evaluations. Periodic medical evaluations are required for Hazmat and Divers but not for other fire fighters. The content of the medical evaluation for these special groups is the same as the preemployment, except the exercise stress test is increased to Stage 4 of the Bruce protocol and the PFT is done immediately after the exercise stress test.

If an employee is injured at work or is ill, the FD medical clinic will evaluate the employee and provide clearance for returning to work. Although all fire

stations have exercise (strength and aerobic) equipment, primarily purchased by the Fire Department, the Department does not have a mandatory fitness program. No wellness programs (smoking cessation, weight control, high blood pressure, diabetes, or cholesterol) are offered by the City.

DISCUSSION

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.[1] Risk factors for its development include increasing age, male gender, family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes.[2] The victim had three of these risk factors (advancing age, male gender, and smoking).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.[3] However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.[4] Heart attacks typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply.[5] This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques. A fresh thrombus in the victim's LAD during the cardiac catheterization and his serial EKGs, cardiac enzymes and autopsy were all consistent with an MI.

Blood clots, or thrombus formation, in coronary arteries are initiated by disruption of atherosclerotic plaques. Certain characteristics of the plaques (size, composition of the cap and core, presence of a local inflammatory process) predispose the plaque to disruption.[5] Disruption then occurs from biomechanical and hemodynamic forces, such as increased blood pressure, increased heart rate, increased catecholamines, and shear forces, which occur during heavy exercise.[6,7]

Fire fighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.[8] Fire-fighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. The increase in heart rate has been shown to begin with responding to the initial alarm and persist through the course of fire suppression activities.[9-11] Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.[12-15] The victim had advanced a 2½-inch hoseline and was performing exterior fire extinguishment while wearing full turnout gear with SCBA (weighing approximately 50-60 pounds total). This is considered a heavy level of physical exertion.

The Department requires a preemployment/ preplacement medical examination for all new hires but does not require periodic medical evaluations for all fire fighters. NFPA recommends a yearly physical evaluation to include a medical history, height, weight, blood pressure, and visual acuity test.[16] NFPA also recommends a thorough examination to include vision testing, audiometry, pulmonary function testing, a complete blood count, urinalysis, and biochemical (blood) test battery be conducted on a periodic basis according to the age of the fire fighter (less than 30, every 3 years; 30-39, every 2 years; over 40 years, every year).

To reduce the risk of heart attacks and sudden cardiac arrest among fire fighters, the National Fire Protection Association (NFPA) has developed guidelines entitled "Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians," otherwise known as NFPA 1582.[16] They recommend, in addition to screening for risk factors for CAD, an exercise stress

EKG, otherwise known as an exercise stress test (EST). The EST is used to screen individuals for CAD. Unfortunately, it has problems with both false negatives (inadequate sensitivity) and false positives (inadequate specificity), particularly for asymptomatic individuals (individuals without symptoms suggestive of angina), young men, and women.[17,18] This has led other expert groups to **not** recommend EST for asymptomatic individuals without risk factors for CAD.[19,20]

When these asymptomatic individuals **have** risk factors for CAD, however, recommendations vary by organization. The American College of Cardiology/American Heart Association (ACC/AHA) identifies four groups for EST although they note that the "usefulness/efficacy is less well established by evidence/opinion."[19]

- Group 1: Persons with multiple risk factors. They define five risk factors for CAD: hypercholesterolemia (total cholesterol greater than 240 mg/dL), hypertension (systolic greater than140 mm Hg or diastolic greater than 90 mm Hg), smoking, diabetes, and family history of premature CAD (cardiac event in first-degree relative less than 60 years old).
- Group 2: Men over the age of 40 and women over the age of 50 (especially if sedentary) who plan to start vigorous exercise.
- Group 3: Men over the age of 40 and women over the age of 50 who are at high risk for CAD due to other diseases (e.g., chronic renal failure).
- Group 4: Men over the age of 40 and women over the age of 50 who are involved in occupations in which impairment might impact public safety.

The U.S. Preventive Services Task Force (USPSTF) does not recommend EST for asymptomatic individuals, even those with risk factors for CAD; rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes).[20]

The USPSTF indicates that there is insufficient evidence to recommend screening middle-age and older men or women in the general population; however, "screening individuals in certain occupations (pilots, truck drivers, etc.) can be recommended on other grounds, including the possible benefits to public safety."[20]

Since the victim was over the age of 40 and had hypertension, according to NFPA 1582 an EST would have been reasonable to perform. An EST might have identified his CAD, thereby leading to further evaluation and treatment and possibly the prevention of this sudden cardiac death.

RECOMMENDATIONS AND DISCUSSION

The following recommendations address health and safety generally. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job cardiac arrest among fire fighters. These recommendations have not been evaluated by NIOSH but represent published research or consensus votes of Technical Committees of the National Fire Protection Association or labor/management groups within the fire service. In addition, they are presented in a logical programmatic order, and are not listed in a priority manner.

Recommendation #1: Fire Fighters should have mandatory annual medical evaluations and periodic physical examinations to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

The content and frequency of this evaluation should be negotiated between the Fire Department and the local union. Guidance can be found in NFPA 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians,[16] and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.[21]

Recommendation #2: Exercise stress tests should be incorporated into the Fire Department's medical evaluation program.

NFPA 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians, and the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative both recommend at least biannual EST for fire fighters.[16,21] They recommend that these tests begin at age 35 for those with CAD risk factors and at age 40 for those without CAD risk factors. The EST could be conducted by the fire fighter's personal physician (at City or Fire Department expense) or the City physician. If the fire fighter's personal physician conducts the test, the results must be communicated to the City physician, who is responsible for decisions regarding medical clearance for fire-fighting duties.

Recommendation #3: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.[22] In 1997, the International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) joined in a comprehensive Fire Service Joint Labor Management Wellness/Fitness Initiative to improve fire-fighter quality of life and maintain physical and mental capabilities of fire fighters. Ten fire departments across the United States joined this effort to pool information about their physical fitness programs and to create a practical fire-service program. They produced a manual and a video detailing elements of such a program.[21] Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.[23,24] A similar cost savings has been reported by the Wellness program at the Phoenix Fire Department, where a 12-year commitment has resulted in a significant reduction in their disability pension costs.[25]

REFERENCES

1. Fauci AS, Braunwald E, Isselbacher KJ, et al. [1998]. Harrison's principles of internal medicine. 14th ed. McGraw-Hill: New York, pp. 222-225.

2. American Heart Association (AHA) [1998]. AHA scientific position, risk factors for coronary artery disease. Dallas, TX.

3. Fauci AS, Braunwald E, Isselbacher KJ, et al. [1998]. Harrison's principles of internal medicine. 14th ed. McGraw-Hill: New York, p. 1348.

4. Shah PK [1997]. Plaque disruption and coronary thrombosis: new insight into pathogenesis and prevention. Clin Cardiol *20*(11)(Suppl2):II-38-44.

5. Fuster V, Badimon JJ, Badimon JH [1992]. The pathogenesis of coronary artery disease and the acute coronary syndromes. N Eng J Med *326*:242-250.

6. Kondo NI, Muller JE [1995]. Triggering of acute myocardial infarction. J Cardiovasc Risk *2*(6):499-504.

7. Opie LH [1995]. New concepts regarding events that lead to myocardial infarction. Cardiovasc Drug Ther *9* Suppl 3:479-487.

8. Gledhill N, Jamnik, VK [1992]. Characterization of the physical demands of firefighting. Can J Spt Sci *17*(3):207-213.

9. Barnard RJ, Duncan HW [1975]. Heart rate and ECG responses of fire fighters. J Occup Med *17*:247-250.

10. Manning JE, Griggs TR [1983]. Heart rate in fire fighters using light and heavy breathing equipment: simulated near maximal exertion in response to multiple work load conditions. J Occup Med *25*:215-218.

11. Lemon PW, Hermiston RT [1977]. The human energy cost of fire fighting. J Occup Med *19*:558-562.

12. Willich SN, Lewis M, Lowel H, et al. [1993]. Physical exertion as a trigger of acute myocardial infarction. N Eng J Med *329*:1684-1690.

13. Mittleman MA, Maclure M, Tofler GH, et al. [1993]. Triggering of acute myocardial infarction by heavy physical exertion. N Eng J Med *329*:1677-1683.

14. Siscovick DS, Weiss NS, Fletcher RH, Lasky T [1984]. The incidence of primary cardiac arrest during vigorous exercise. N Eng J Med *311*:874-877.

15. Tofler GH, Muller JE, Stone PH, et al [1992]. Modifiers of timing and possible triggers of acute myocardial infarction in the Thrombolysis in Myocardial Infarction Phase II (TIMI II) Study Group. J Am Coll Cardiol *20*:1049-1055.

16. National Fire Protection Association [2000]. NFPA 1582, standard on medical requirements for fire fighters and information for fire department physicians. Quincy, MA: National Fire Protection Association.

17. Michaelides AP, Psomadaki ZD, Dilaveris PE [1999]. Improved detection of coronary artery disease by exercise electrocardiography with the use of right precordial leads. New Eng J Med *340*:340-345.

18. Darrow MD [1999]. Ordering and understanding the exercise stress test. American Family Physician. January 15, 1999.

19. Gibbons RJ, Balady GJ, Beasley JW, Bricker JT, Duvernoy WFC, Froelicher VF, Mark DB, Marwick TH, McCallister BD, Thompson PD, Winters WL Jr, Yanowitz FG. ACC/AHA guidelines for exercise testing: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Exercise Testing). J Am Coll Cardiol *30*:260-315.

20. U.S. Preventive Services Task Force [1996]. Guide to clinical prevention services. 2nd ed. Baltimore, MD: Williams & Wilkins, pp. 3-15.

21. International Association of Fire Fighters [1997]. The fire service joint labor management wellness/fitness initiative. Washington, D.C.: International Association of Fire Fighters, Department of Occupational Health and Safety.

22. National Fire Protection Association [1997]. NFPA 1500, standard on fire department occupational safety and health program. Quincy, MA: National Fire Protection Association.

23. National Institute of Consulting Services, 1996.

24. Maniscalco P, Lane R, Welke M, Mitchell J, Husting L [1999]. Decreased rate of back injuries through a wellness program for offshore petroleum employees. J Occup Environ Med *41*:813-820.

25. City Auditor, City of Phoenix, AZ [1997]. Disability retirement program evaluation. January 28, 1997.

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